

# TECHNETIUM-99m MAG3 AND TECHNETIUM-99m DMSA IN CHILDREN WITH RENAL DISEASES

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Children with renal diseases were studied with Technetium-99m MAG3 and Technetium-99m DMSA scans. This hospital based descriptive study included 52 consecutive children with urinary tract infection and hydronephrosis who underwent a renogram and renal scan in Nuclear Medicine Department, Yangon General Hospital between November 2015 and October 2016. Data were collected on age, urinary symptoms, urine culture and referred by Pediatrician and images were interpreted by an experienced nuclear medicine physician and results were analyzed. Most of the patients were under 3 years of age. Male was more common than female. Split renal function (SRF) assessed by <sup>99m</sup>Tc-MAG3 was found to correlate with <sup>99m</sup>Tc-DMSA. Cortical defects were observed equally on <sup>99m</sup>Tc-MAG3 and <sup>99m</sup>Tc-DMSA. <sup>99m</sup>Tc-MAG3 had sensitivity 94.1%, specificity 91.4 %, positive predictive value 84.2%, negative predictive value 96.9% and accuracy 90.3% for both kidneys as compared to those of <sup>99m</sup>Tc-DMSA. <sup>99m</sup>Tc-DMSA is the gold standard method for detecting parenchymal lesions and assessing SRF. <sup>99m</sup>Tc-MAG3 provides adequate images for assessment of renal cortex and accurate measurement of SRF comparable with <sup>99m</sup>Tc-DMSA results. In addition, it provides important information on the urodynamic of both kidneys and avoids unnecessary radiation burden to the children, as well as is time saving. It is considered that this is time to replace the <sup>99m</sup>Tc-DMSA with <sup>99m</sup>Tc-MAG3 in most nephrologic disorders in pediatric patients and to keep the former for doubtful cases obtained using the latter.

*Key Words:* <sup>99m</sup>Tc-MAG3, <sup>99m</sup>Tc-DMSA, split renal function, renal cortex, urinary tract infection, hydronephrosis.

## INTRODUCTION

Radionuclide renal studies are performed in infants and children and play a prominent role in the diagnosis and follow-up of various kidney diseases which can lead to end stage renal disease. Amongst them, this study focused on urinary tract infection and hydronephrosis. There are many investigations (Ultrasonography (USG), KUB X ray, Intravenous Pyelography (IVP) and Computed Tomography (CT)) to detect the anatomical abnormalities of the disease and to decide management plan. <sup>99m</sup>Tc-MAG3 (Mercaptoactyltriglycine) and <sup>99m</sup>Tc-DMSA (Dimercaptosuccinic acid) radionuclide imagings are the functional investigations of renal parenchymal evaluation such as split renal function and cortical scarring, particularly in the follow-up of urinary tract infection and hydronephrosis. Urinary tract infection occurs in 4-8% of febrile infants and is a common and important clinical problem in childhood. A total of 183 urinary tract infection patients attended Yangon Children

Hospital in 2014 (YCH registry, 2014).

Obstructive uropathy such as hydronephrosis is a major cause of renal impairment in infants and children. Dilatation of the renal pelvis is due to an obstruction to the outflow or a simple anatomic variant. When surgical intervention is indicated so as to preserve renal function in patients with nonfunctioning or poorly functioning kidneys, it may need to know SRF. There were 59 patients with hydronephrosis attended Yangon Children Hospital in 2014 (YCH registry, 2014).

Radionuclide renal imaging provides unique functional and anatomic information with minimal risk to the patient. <sup>99m</sup>Tc-DMSA is the most commonly used radiopharmaceutical to detect renal scarring and to provide accurate split renal function (20). <sup>99m</sup>Tc-DMSA cortical scan is generally the gold standard procedure for estimation of split renal function and assessment of cortical integrity (1). However, the long residence

time of  $^{99m}\text{Tc}$ -DMSA in the renal cortex leads to high radiation dose to the patient, which is one of the major limitations of the test (10).

$^{99m}\text{Tc}$ -MAG3 is a renal plasma flow agent as well as a tubular secreting agent. Its renal clearance is very fast (within minutes).  $^{99m}\text{Tc}$ -MAG3 scan can provide adequate images for assessment of renal cortex and accurate measurement of split renal function. In addition,  $^{99m}\text{Tc}$ -MAG3 scan can provide important information about urodynamic of both kidneys. Therefore,  $^{99m}\text{Tc}$ -DMSA renal scan should be replaced with  $^{99m}\text{Tc}$ -MAG3 in most nephrologic disorders in pediatric patients and keep  $^{99m}\text{Tc}$ -DMSA renal scan for the doubtful cases.

## MATERIALS AND METHODS

A hospital based cross sectional descriptive study was done at Department of Nuclear Medicine, Yangon General Hospital. Total 52 pediatric patients with renal diseases referred from Yangon Children Hospital and Yankin Children Hospital from November 2015 to October 2016 were studied. Two studies were done 24 hours apart. First was  $^{99m}\text{Tc}$ -MAG3 to detect renal parenchymal lesions and assess split renal function.  $^{99m}\text{Tc}$ -DMSA scan were done after 24 hours for these purposes with Gamma camera with SPECT (SIEMENS E.cam, Germany, Model 4381047/2003).

$^{99m}\text{Tc}$ -MAG3 and  $^{99m}\text{Tc}$ -DMSA were administered according to Webster's equation.

$$A\text{-child} = \frac{[(N+1) \cdot A\text{-adult}]}{(N+7)}$$

Where N= age of the child [year]

AAdult , A child: activity [MBq]

Data collected from the proforma was entered into the computer using statistical software SPSS Version 16.0 (Statistical Package for Social Science Version 16). Split renal function was assessed by  $^{99m}\text{Tc}$ -MAG3 and  $^{99m}\text{Tc}$ -DMSA by using Chi-Square Test, significant level was set at 0.05 level. Sensitivity, specificity, predictive values and overall accuracy of  $^{99m}\text{Tc}$ -MAG3 for detecting renal parenchymal lesions, using the result of  $^{99m}\text{Tc}$ -DMSA scan as gold standard.

## RESULTS

During one year study period, 52 cases of pediatric patients with urinary tract infection and hydronephrosis. In this study, ages of the patients ranged from 1 month to 12 years and the mean age was 4.37 years. Most of the patients were under the age of 3 years. 32 patients were male (61.5%) and 20 patients were female (38.5%). Urinary tract infection and hydronephrosis were diagnosed 30.8% and 69.2% respectively. Hydronephrotic patients are more than half of study population.

Figure 1 and 2 show correlation between split renal function (SRF) using  $^{99m}\text{Tc}$ -MAG3 versus  $^{99m}\text{Tc}$ -DMSA. The figures show most of the data are scattered around the straight line upward trend from left to right. Pearson correlation for these two methods was 0.808 (p value <0.001). Thus these two methods were positively and significantly correlated with each other.

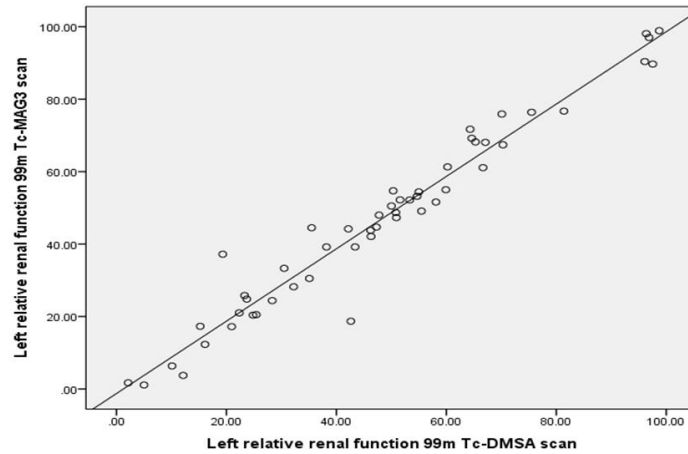
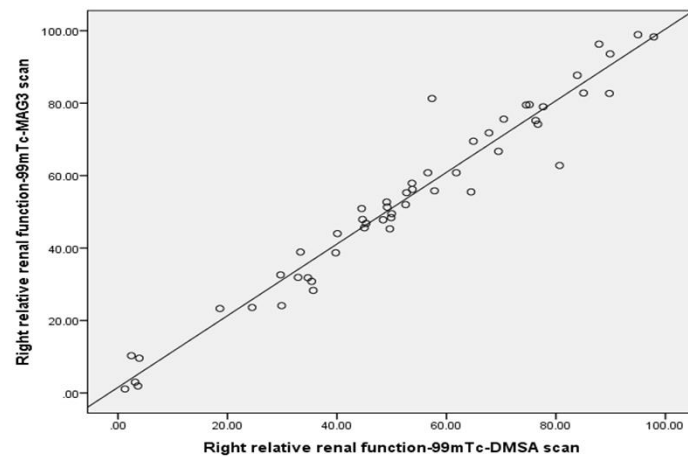


Figure (1) Correlation between left SRF using  $^{99m}\text{Tc-MAG3}$  versus  $^{99m}\text{Tc-DMSA}$



Figure(2) Correlation between right SRF using  $^{99m}\text{Tc-MAG3}$  versus  $^{99m}\text{Tc-DMSA}$

Table (1) Cross-tabulation of presence of parenchymal lesion between  $^{99m}\text{Tc-MAG3}$  scan and  $^{99m}\text{Tc-DMSA}$  scan

Lesion detected by $^{99m}\text{Tc-DMSA}$ scan	Lesion detected by $^{99m}\text{Tc-MAG3}$ scan		Total
	Present	Absent	
Present	32 (94.1%)	6 (8.6%)	38 (36.5%)
Absent	2 (5.9%)	64 (91.4%)	66 (63.5%)
Total	34 (100.0%)	70 (100.0%)	104 (100.0%)

Table (1) showed among 38 patients who had parenchymal lesions detected by  $^{99m}\text{Tc-DMSA}$ , 32 patients (94.1%) had lesions and 6 patients (8.6%) had no lesions when assessed by  $^{99m}\text{Tc-MAG3}$ . Among 66 patients who had no parenchymal lesions detected by  $^{99m}\text{Tc-DMSA}$ , 2 patients (5.9%) had lesions and 64 patients (91.4%) had no lesions when assessed by  $^{99m}\text{Tc-MAG3}$ .

## DISCUSSION

Valuable data on renal perfusion and the parenchymal and dynamic function of individual kidney as well as on urinary tract dynamics can be provided by Nuclear medicine procedures to clinicians.

Different renal tracers have been offered for evaluating different renal functions. However, in the diagnostic techniques that use ionizing radiation, many factors such as reduced radiation dose, non-invasiveness, shorter take-up time as well as more detailed information are considered.

In this study, total of 52 pediatric patients (104 kidneys) with urinary tract infection and hydronephrosis were enrolled to study the association between  $^{99m}\text{Tc}$ -MAG3 and  $^{99m}\text{Tc}$ -DMSA in detecting parenchymal lesions and assessing split renal function (SRF). In the current study, most of the patients were under 3 years of age and most of them were male patients. Thein Thein Hnin (1994) identified that most of the patients were preschool age (3-5) years and most of them were females with asymptomatic bacteriuria. Our study included UTI as well as hydronephrosis and most of them were hydronephrotic patients.

In the current study, correlation between SRF using  $^{99m}\text{Tc}$ -MAG3 and  $^{99m}\text{Tc}$ -DMSA in both kidneys shows that most of the data are scattered around the straight line upward trend from left to right. Pearson correlation for these two methods were 0.858 (p value <0.001). So these two methods were positively and significantly correlated with each other.

Smokvina A et al (2005) mentioned that there were statistically significant correlation in 188 patients with renal diseases (Chi square 7.92, p value- 0.01) in assessing SRF by  $^{99m}\text{Tc}$ -MAG3 renography and  $^{99m}\text{Tc}$ -DMSA renal scan. Ritchie G et al (2008) also mentioned that there was no clinically significant difference between SRF calculated using  $^{99m}\text{Tc}$ -DMSA and that calculated using  $^{99m}\text{Tc}$ -MAG3 renography (p= 0.0012). In their study, 92 children were studied for assessing SRF by using  $^{99m}\text{Tc}$ -MAG3 and  $^{99m}\text{Tc}$ -DMSA. In our study, p value <0.001 and there were significantly correlated between  $^{99m}\text{Tc}$ -MAG3 and  $^{99m}\text{Tc}$ -DMSA in assessing SRF.

So these two methods were positively and significantly correlated with each other.

Othman S et al (2012) also stated that the scintigraphic results as measured by  $^{99m}\text{Tc}$ -DMSA scan had very close results when measured by functional  $^{99m}\text{Tc}$ -MAG3 images, with statistically significant correlation of SRF as measured by  $^{99m}\text{Tc}$ -DMSA scan and  $^{99m}\text{Tc}$ -MAG3 renogram of both kidneys. They studied 52 patients with renal diseases and all of them were studied by  $^{99m}\text{Tc}$ -DMSA and  $^{99m}\text{Tc}$ -MAG3. In the present study, p value <0.001 and there were significantly correlated between  $^{99m}\text{Tc}$ -MAG3 and  $^{99m}\text{Tc}$ -DMSA in assessing SRF.

Abdulrezzak et al (2013) evaluated 64 patients for SRF. There were no statistically significant differences between  $^{99m}\text{Tc}$ -MAG3 and  $^{99m}\text{Tc}$ -DMSA images in SRF calculation (p > 0.005) and there was a high correlation between the two methods (Pearson correlation, r = 0.986). Our study showed that Pearson correlation for these two methods were 0.858 (p value <0.001). So these two methods were positively and significantly correlated with each other.

In the present study, the sensitivity, specificity, positive predictive value, negative predictive value and accuracy of  $^{99m}\text{Tc}$ -MAG3 in detecting parenchymal lesions were 94.1%, 91.4%, 84.2%, 96.9% and 92.3% respectively. Otukesh et al (2007) mentioned that there were 87% sensitivity, 100% specificity, 100% positive predictive value, 62.5% negative predictive value and 89.3% accuracy of  $^{99m}\text{Tc}$ -MAG3 as compared with  $^{99m}\text{Tc}$ -DMSA. In this study, false negative kidneys were diagnosed as complicated UTI and false positive kidneys were hydronephrotic kidneys.

Sfakianakis G N et al (2000) indicated that  $^{99m}\text{Tc}$ -MAG3 by revealing regional parenchymal dysfunction or fixed focal defects, there were as sensitive as  $^{99m}\text{Tc}$ -DMSA, with the advantage of providing results within 25 minutes rather than 3-4 hours.

Smokvina A et al (2005) also stated that most of the parenchymal lesions detected on  $^{99m}\text{Tc}$ -DMSA scan can be identified on  $^{99m}\text{Tc}$ -MAG3 renogram. They studied 188 patients and the distribution and outlines were interpreted as normal, equivocal or as a clear lesion. There was no visual difference between the two scans. The results of current study were comparable with those of other study. Therefore,  $^{99m}\text{Tc}$ -DMSA scan could be used for uncertain or inconclusive  $^{99m}\text{Tc}$ -MAG3 findings only.

Although specificity of  $^{99m}\text{Tc}$ -MAG3 was 91.4% and NPV was 96.9% as compared with  $^{99m}\text{Tc}$ -DMSA in the present study, Othman et al (2012) stated that  $^{99m}\text{Tc}$ -MAG3 study provides adequate images for assessment of renal cortex and therefore, promoting  $^{99m}\text{Tc}$ -MAG3 as an alternative agent to  $^{99m}\text{Tc}$ -DMSA in most nephrologic disorders in pediatric patients and keeping the latter to doubtful cases.

Abdulrezzak et al (2013) showed that  $^{99m}\text{Tc}$ -DMSA scintigraphy was considered the reference technique, the sensitivity, specificity, accuracy, PPV and NPV of  $^{99m}\text{Tc}$ -MAG3 for detecting renal parenchymal lesions were calculated as 92.6%, 96.8%, 95.5%, 92.6% and 96.8% respectively. There were no marked differences between the two studies. In the current study, the sensitivity was 94.1%, specificity was 91.4%, PPV was 84.2%, NPV was 96.9% and accuracy was 90.3% which is comparable with other study.

Current study showed measurement of SRF by  $^{99m}\text{Tc}$ -MAG3 and  $^{99m}\text{Tc}$ -DMSA

was nearly equal or the difference is within acceptable limit therefore the same result as compared to other study. However, the specificity, NPV and accuracy were less than other study result because of limited study by subject enrollment criteria, as each subject enrolled in this study was referred by Pediatrician (hospital based method) and the subjects were children so movement occurred during scanning time.

Another limitation for our study was the low sample size. Moreover, the summed  $^{99m}\text{Tc}$ -MAG3 images were quite noisy, giving a high positive rate (low specificity).

In conclusion, this study shows that the sensitivity, specificity, PPV, NPV and accuracy of  $^{99m}\text{Tc}$ -MAG3 were calculated as 94.1%, 91.4%, 84.2%, 96.9% and 90.3% respectively or detecting renal parenchymal lesions as compared with  $^{99m}\text{Tc}$ -DMSA. This study also points that there were significantly associated with each other in assessing SRF by using  $^{99m}\text{Tc}$ -MAG3 and  $^{99m}\text{Tc}$ -DMSA. Moreover,  $^{99m}\text{Tc}$ -MAG3 shows urodynamic of kidneys.

The greatest advantage of  $^{99m}\text{Tc}$ -MAG3 is the low radiation absorbed dose (0.25mGy/ MBq), whole body dose, as compared with  $^{99m}\text{Tc}$ -DMSA (1.60 mGy/ MBq, whole body dose) (1). This change in practice would therefore result in considerable savings in time, cost and radiation burden. Therefore,  $^{99m}\text{Tc}$ -MAG3 can be used as the sole test in renal diseases such as UTI and hydronephrosis, especially in children.

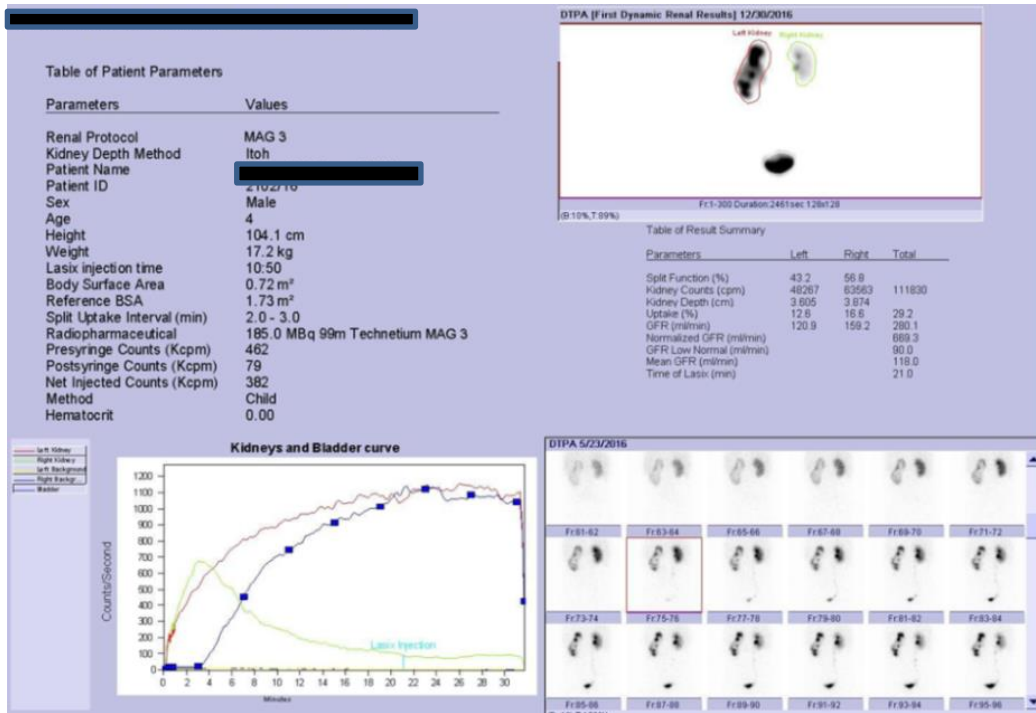


Figure (3) <sup>99m</sup>Tc MAG 3 renogram of 4 year old child with hydronephrosis

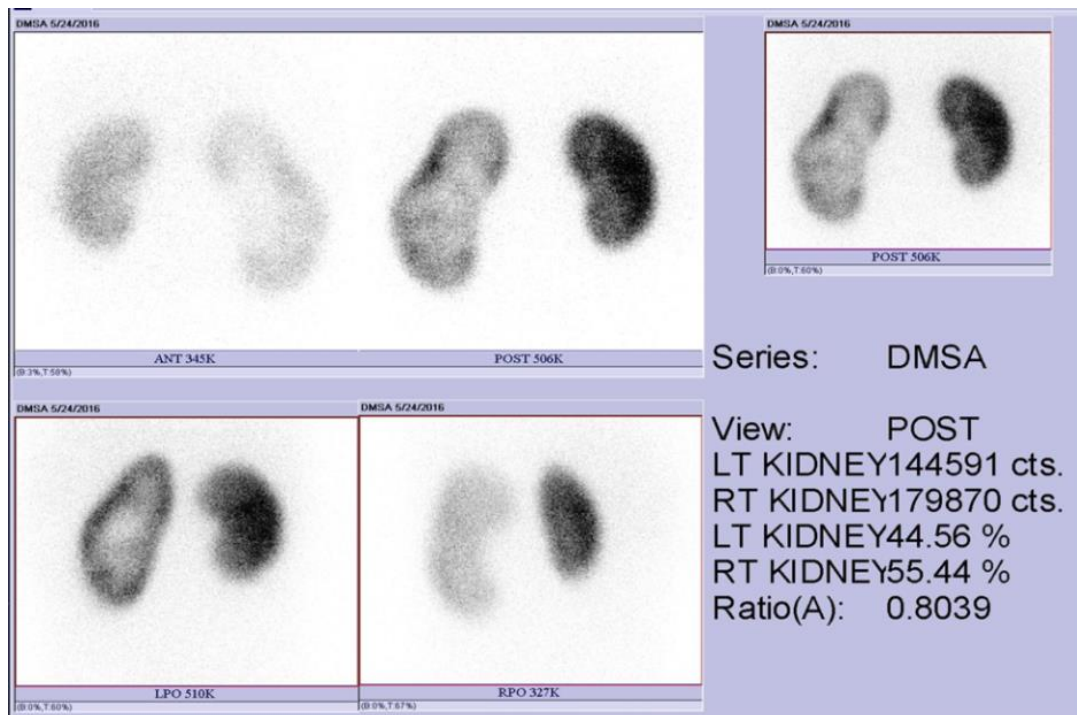


Figure (4) <sup>99m</sup>Tc DMSA renal scan of same child with hydronephrosis as <sup>99m</sup>Tc MAG 3 renogram

Normal right kidney ( Normal in size and shape of uniform radiotracer distribution) and hydronephrotic left kidney (Photon

deficient areas are seen in enlarged left kidney) SRF Right 55.44%, Left 44.56%

## CONCLUSION

A total number of 52 cases of children with urinary tract infection and hydronephrosis were studied during the study period. According to the study, there is a statistically significant correlation between  $^{99m}\text{Tc}$ -MAG3 and  $^{99m}\text{Tc}$ -DMSA in assessing split renal function. It has been demonstrated in the current study that  $^{99m}\text{Tc}$ -MAG3 had sensitivity 94.1%, specificity 91.4%, positive predictive value 84.2%, negative predictive value 96.9% and accuracy 90.3% for both kidneys as compared with  $^{99m}\text{Tc}$ -DMSA renal scan for detecting parenchymal lesions.  $^{99m}\text{Tc}$ -DMSA is the gold standard investigation in the assessment of renal cortical lesions and split renal function.  $^{99m}\text{Tc}$ -MAG3 study provides adequate images for assessment of renal cortex and accurate measurement of SRF comparable with  $^{99m}\text{Tc}$ -DMSA scan results. In addition, it provides visualization of the collecting system and important information on the urodynamic of both kidneys and avoids unnecessary additional radiation to the children and as well as time saving. Therefore the findings of this study points out replacing  $^{99m}\text{Tc}$ -DMSA with  $^{99m}\text{Tc}$ -MAG3 in the initial assessment of most nephrologic disorders in pediatric patients.

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